Name of Organization: Wayne State University

Type of Organization: College or University

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Project Title: Distributed Wastewater Treatment for Detroit River Basins

Project Category: Emerging Issues

Rank by Organization (if applicable): 0

Total Funding Requested ($): 58,552 **Project Duration:** 1 Years

Abstract:

How to develop a wastewater treatment network is a key for effective protection of water quality of a lake or river in an urban area. This decision largely determines the effectiveness of the infrastructure of an overall wastewater treatment system in a city. In Detroit, wastewater is generated from different industrial, residential, commercial, and agricultural areas. The wastewater of point and non-point sources is normally sent to the City's centralized Wastewater Treatment Plant (CenWWTP) before entering to the Detroit River. Although it is already the largest in the world, the plant still can not take all amount of wastewater during wet weather. An expansion of its capacity is always out of consideration due to extremely high cost. In fact, it is undesirable to do so technically. Note that wastewater streams from different sources contain different pollutants with different contamination levels. It is certainly unwise to mix them first in sewer systems and then separate them in the CenWWTP. The most desirable strategy is to establish a distributed wastewater treatment network (DisWWTN). In this proposal, we intend to develop a novel, general methodology for designing an optimal DisWWTN using the wastewater pinch technology, the large scale system optimization theory and fuzzy logic. We focus on the Detroit River basin for which we have already developed a CSO model that is in SEMCOG's GIS system. We intend to help the City: (i) analyze the current annual loadings of PCB, mercury, lead, chlordane, etc., into the River through CSO, (ii) assess the economic, technical, and environmental feasibility of developing a DisWWTN, and (iii) propose the most desirable strategy for the DisWWTN through enhancing existing localized WWTP's. Comprehensive economic comparison of a DisWWTN and a CenWWTP will be conducted. This methodology will be applicable to any regions of the Great Lakes.

Geographic Areas Affected by the Project

States:

- [x] Illinois
- [x] Indiana
- [x] Michigan
- [ ] Minnesota
- [ ] New York
- [ ] Pennsylvania
- [ ] Wisconsin
- [x] Ohio

Lakes:

- [ ] Superior
- [ ] Huron
- [ ] Michigan
- [ ] Erie
- [ ] Ontario
- [x] All Lakes

Geographic Initiatives:

- [ ] Greater Chicago
- [ ] NE Ohio
- [ ] NW Indiana
- [x] SE Michigan
- [ ] Lake St. Clair

Primary Affected Area of Concern: All AOCs

Other Affected Areas of Concern:

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

In an urban area, such as in Detroit, wastewater from numerous point and non-point sources contains various persistent toxic substances, such as alkyl-lead, B(a)P, HCB, mercury, PCBs, aldrin/dieldrin, chlordane, DDT, and toxaphene. In Detroit, wastewater from different regions is always mixed in sewer systems and then sent to the Detroit Wastewater Treatment Plant (a centralized plant, or CenWWTP), before entering the Detroit River. During wet weather, a large portion of the wastewater is discharged into the River directly through 47 CSO discharge locations since the CenWWTP can not take it all, although its capacity is already the world's largest. An expansion of the plant is always out of consideration because of the huge capital requirement. In fact, such an expansion is technically very undesirable. Note that wastewater streams from different sources contain different pollutants with different contamination levels. It is very unwise to mix them first in sewer systems and then separate them in a CenWWTP. The most desirable strategy is to establish a distributed wastewater treatment network (DisWWTN) in an urban area. Unfortunately, such a technology is not available in the U.S. The PI has been actively working with the City of Detroit and SEMCOG on Detroit River water quality. He is one of the two founders of the Detroit River RAP P2 Team under the U.S. Steering Committee. The P2 team has been also working with the CSO Team on the river issues. His experience and close working relationship with the City, local governments, and local industries should ensure the success of the implementation of this project.

Proposed Work Outcome:

In this proposal, we will develop a novel, general, and practical methodology for designing an optimal DisWWTN using the wastewater pinch technology, the large scale system optimization theory and fuzzy logic. The main focus is the Detroit River basin, for which the PI's group has already developed a CSO model for the Detroit River that is in SEMCOG's GIS system. This project should help the City: (i) analyze the current annual loadings of PCB, mercury, lead, chlordane, etc., into the Detroit River through CSO, (ii) assess the economic, technical, and environmental feasibility of developing a DisWWTN, and (iii) propose the most desirable strategy for the DisWWTN through enhancing existing localized WWTP's. Comprehensive economic comparison of a DisWWTN and a CenWWTP will be conducted. The major tasks are briefly described below.

Task 1. To use our CSO model to predict the discharge of toxic substances, such as alkyl-lead, B(a)P, HCB, mercury, PCBs, aldrin/dieldrin, chlordane, DDT, and toxaphene, into the Detroit River. The main difficulty of this effort is the existence of numerous uncertainties (such as storm runoff information), incompleteness (such as limited sample data), and impreciseness (such as unknown sewerage networks). We will use fuzzy logic techniques to improve the CSO model predictability. The PI has guided two Ph.D. students (now graduated) on the CSO and wastewater allocation using fuzzy logic. This work will be accomplished with the assistance from the SEMCOG GIS personnel. We will use the USGS

1994-95 CSO sampling database and the City of Detroit Department of Industrial Wastewater Control database in this task.

Task 2. To analyze the toxic pollutant discharge levels in five different zones of the Detroit River basin. We will set the indicators for the discharge levels of the key pollutants in these zones. We will particularly relate these predictions to land uses (industrial, agricultural, residential, commercial, etc.). This analysis will be also related to the type and capacity of the existing local wastewater treatment facilities (WWTF's). This effort will generate a complete picture of the distribution of targeted pollutants in the focused areas and identify the discrepancy of current localized wastewater treatment strategy.

Task 3. To make optimal decisions on a DisWWTN for the Detroit River basin. In this work, the Water Pinch technology and large-scale optimization theory will be used. The objective of the optimization is to minimize the loading of the targeted pollutants with the lowest total costs for enhancing and/or constructing a number of small-scale local WWTF's distributed in the Detroit area. The constraints of the optimization scenario include the discharge limits of targeted pollutants into the Detroit River and land uses. Complete economic analysis on the enhancement of a DisWWTN and the expansion of current CenWWTP will be conducted. We will use the state-of-art package, GAMS, in optimal decision making.

To the best of the PI's knowledge, this project will be the first effort on the large scale planning and decision making for distributed (or decentralized) wastewater treatment for global river water quality control. This development can also provide the most reliable answers to the following questions that usually critical for any lake and river basin areas: (i) what is the main cause of high concentrations of targeted pollutants in CSO's to a river? (ii) where do these pollutants mainly come from, and what are their loadings? (iii) what is the most cost-effective way to reduce the targeted pollutant discharge (through wastewater allocation or on-site treatment)? (iv) if the treatment capacity of an existing CenWWTP is not enough, what is the most economical solution? (v) where are the best locations for distributed small-scale wastewater treatment facilities? and (vi) for each of such small facilities, what is its capacity and what are the pollutants mainly to be dealt with? It is believed that to have a long range planning for a DisWWTN is the most economic way for water quality control in a river and lake. The success of this project should have wide application potentials for the Great Lakes.

Project Milestones:	**Dates:**
Analyze targeted pollutant discharges	07/2000
Assess existing localized WWTF's	09/2000
Develop a DisWWTN for the Detroit River	11/2000
Compare a CenWWTP and DisWWTN	03/2001
Develop a strategic DisWWN plan	05/2001
Incorporate the DisWWTN into GIS	06/2001
Generate a final report	07/2001
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☒ Project Addresses Environmental Justice

If So, Description of How:

In this project, a number of people in the Detroit River RAP P2 Team will participate in various activities. This group of people, including minorities from academia, City of Detroit, various industries and local governments will work together to accomplish the tasks defined for this project.

☒ Project Addresses Education/Outreach

If So, Description of How:

Environmental engineers and city development planners will be educated through a workshop which is to be organized by the PI. This workshop will help them: (i) understand the importance of the distrubuted wastewater treatment strategy, (ii) learn how to implement the concept of this strategy, and (iii) know how to conduct both economic and environmental analysis of different wastewater treatment approaches.

This project will also support one Ph.D. student to conduct the proposed research in the PI's group. This will eventually help the local govenment/industry generate a highly qualified researcher for environmental planning and wastewater reduction and management, and river water quality protectioin. Wayne State University is one of the largest non-HBCU minority universities in the U.S. The PI will make every effort to identify a minority student for this project.

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	29,000	2,000
Fringe:	10,255	700
Travel:	500	0
Equipment:	0	0
Supplies:	500	0
Contracts:	0	0
Construction:	0	0
Other:	0	0
Total Direct Costs:	40,255	2,700
Indirect Costs:	18,297	0
Total:	58,552	2,700
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

No funding is available or committed now. The PI, however, has been contacting Michigan Department of Environmental Quality and the City of Detroit (DWSD) to seek funding at level of $60,000. Morever, the PI is preparing a proposal for this year's EPA/NSF Technology for Sustainable Environrenment Program for conducting the fundamental research on optimal decentralized wastewater treatment.

Description of Collaboration/Community Based Support:

During the past three years, the PI and Dr. Ralph Kummler have worked with SEMCOG, City of Detroit, USGS, and MDEQ on the project, Detroit River Combined Sewer Overflow Toxics Sampling and Modeling Project. In that project, the PI and Prof. Kummler guided a Ph.D. student to develop a first principles-based, simplified CSO model to predict toxic pollutants discharged through CSO to the Detroit River. The model has been validated using some historical and USGS 1994-95 CSO sampling data. A model-based computer prediction program has been loaded on the SEMCOG GIS system. In this project, the PI will work with the Detroit River RAP P2 Team of whicht the PI is a founder, the City of Detroit (DWSD), and SEMCOG personnel. A special team will be formed as an advisory committee to ensure the success of the project implementation.